Muon Wheel/Disk Alignment Constants from HIP

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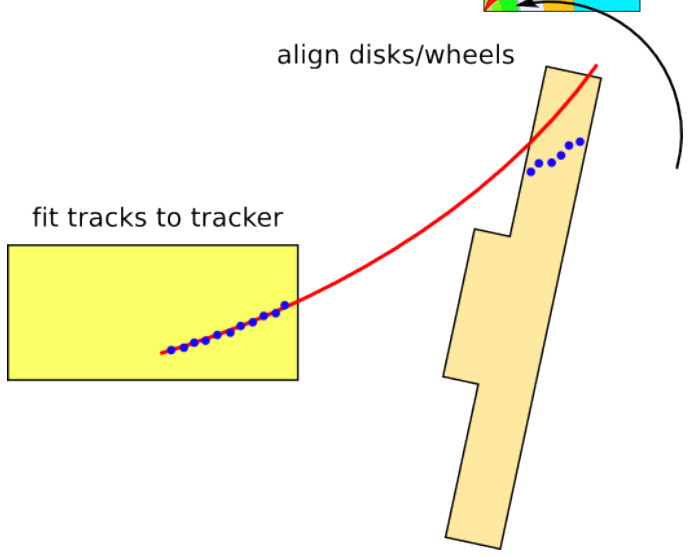
Outline

- Reminder of method
- Alignment results

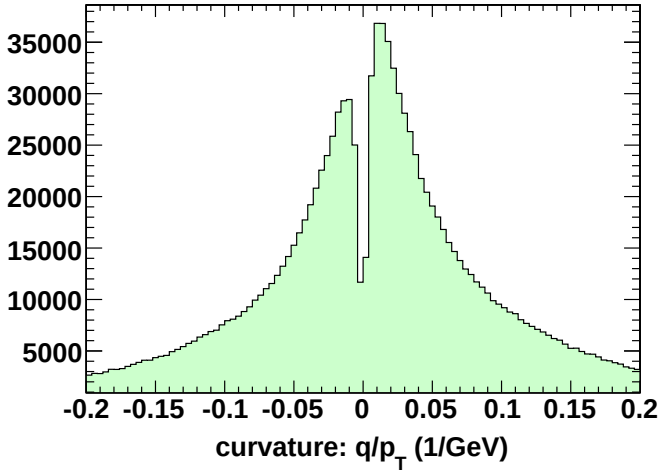


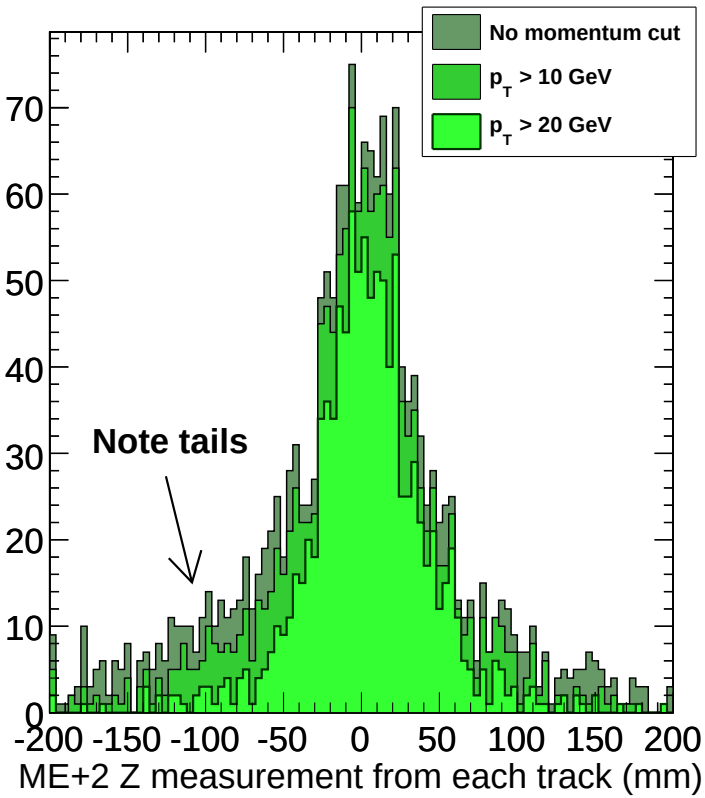
Reminder of method

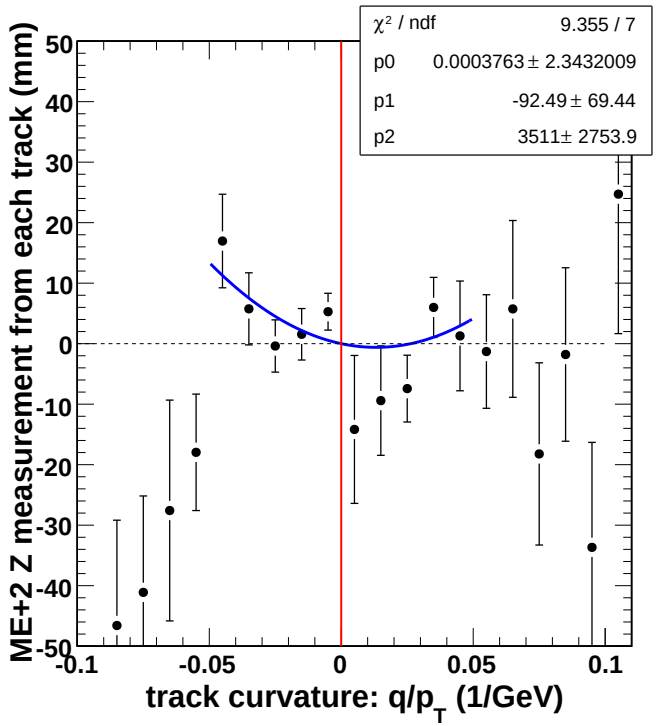
- Treat 5 barrel wheels and 6 out of 8 endcap disks as 6-dof rigid bodies
- Select CRAFT global cosmic rays passing through tracker and wheel/disk
- Fit tracker part, propagate to wheel/disk, align wheel/disk
  - ME$\pm$4/1 and inner rings (ME$\pm$1/1, 2/1, 3/1) are nearly inaccessible (dozens of poor-quality tracks)
  - track-fitting and alignment step are independent, they do not require iteration to resolve any correlation between them
- Every track residual can be converted into 6-dof alignment corrections

Selecting tracks by p_T

- CRAFT offers new ability to reject low-momentum tracks
- Observe each alignment parameter as a function of curvature (q/p_T)
- Cleanest measurement is above 20 GeV



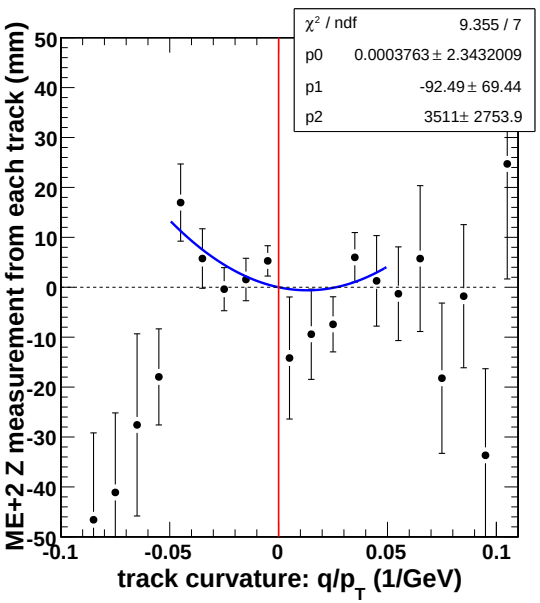




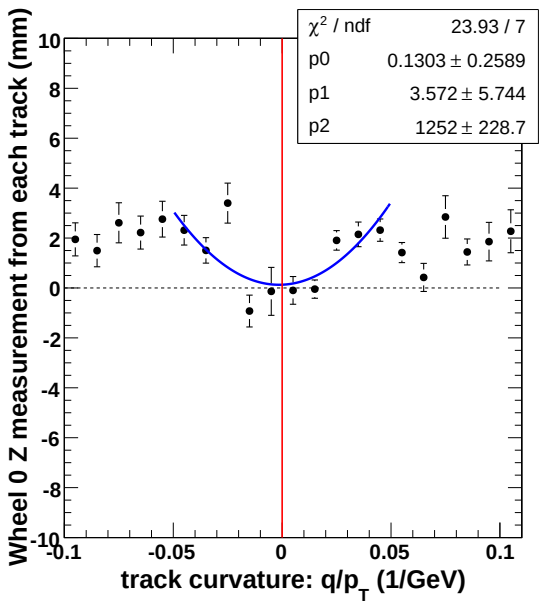
$p \to \infty$ extrapolation

- Multiple scattering and $\vec{B}$ errors limit to zero at infinite momentum
  - multiple scattering is symmetric (independent of q)
  - $\vec{B}$ errors are antisymmetric with q
  - both depend on track angles and detailed track distribution
- Taylor-expand around $q/p_T = 0$ up to second order
- Constant term (p_0) is the misalignment: alignment minimizes p_0
- Linear term (p_1) is $\vec{B}$ error, sensitive to $\pm$0.0007-0.02 T (dep. on η)

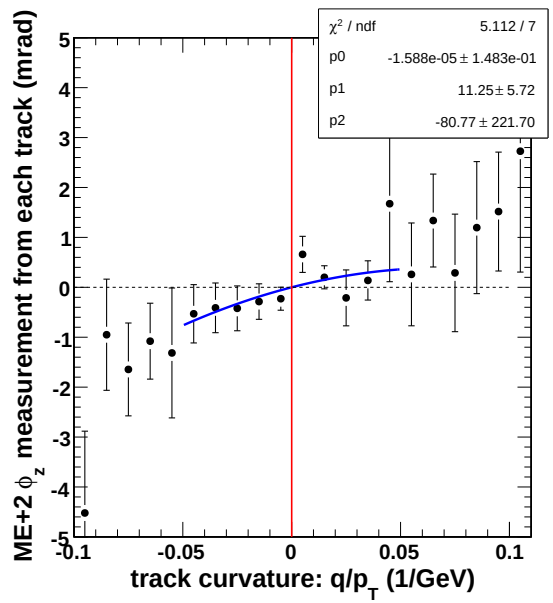
ME+2 z



Wheel 0 z



ME+2 ϕ_z

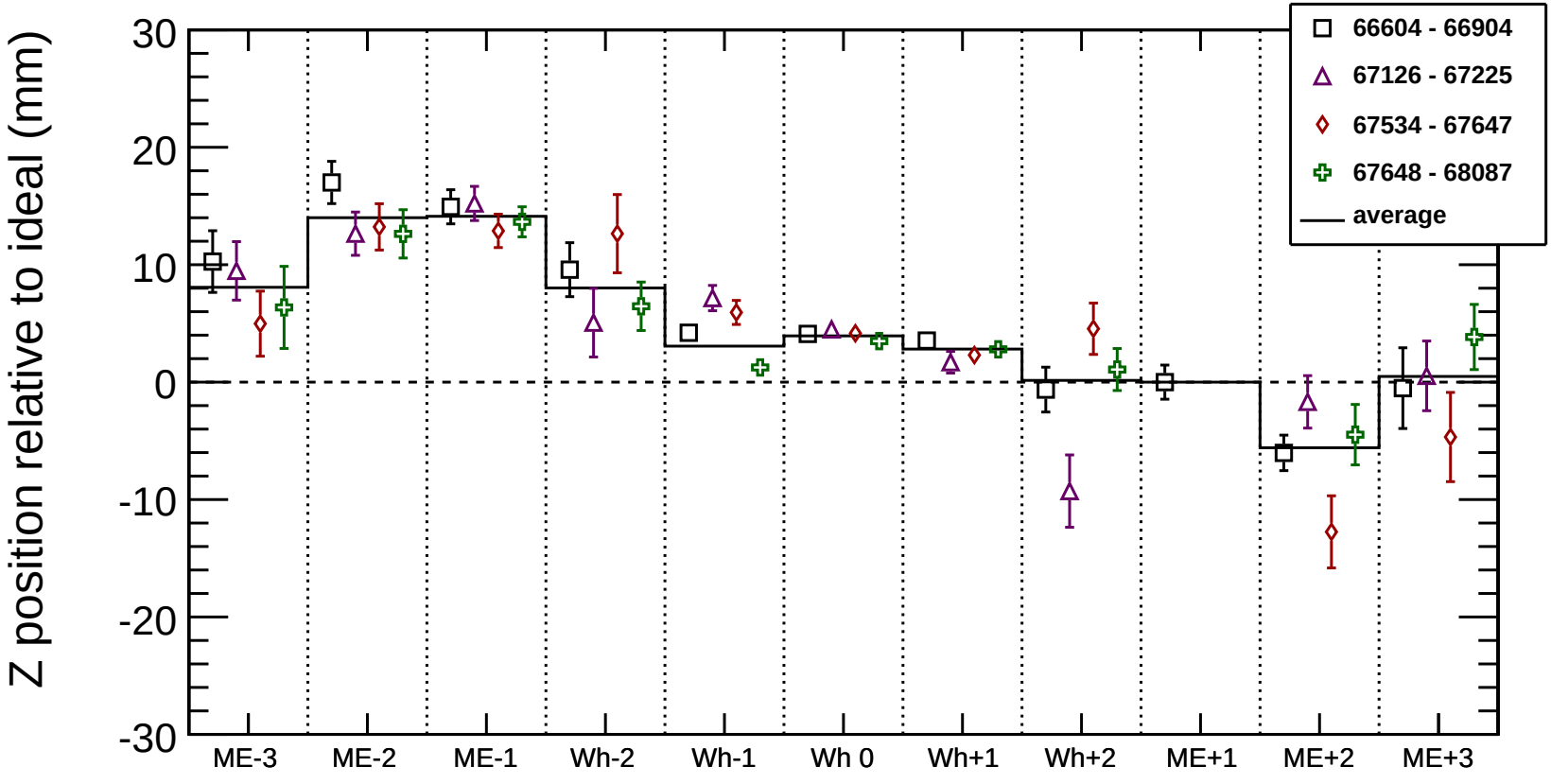


Details

- Barrel and endcap are treated equally
- Hits in the same chamber/superlayer on the same track are combined, so that profile-plot error bars are meaningful: fit-uncertainty in p_0 is the alignment uncertainty
- Wheels internally maintain the relative alignment of chambers
- Disks are aligned with tracks passing through outer ring only (allows them to maintain inner ring correction from hardware measurement)
- Quality cuts: tracker $\chi^2/N_{\text{dof}} < 20$, $N_{\text{tracker hits}} \geq 10$, at least 500 tracks per alignable
- Iterate to verify residual $\longrightarrow 0$

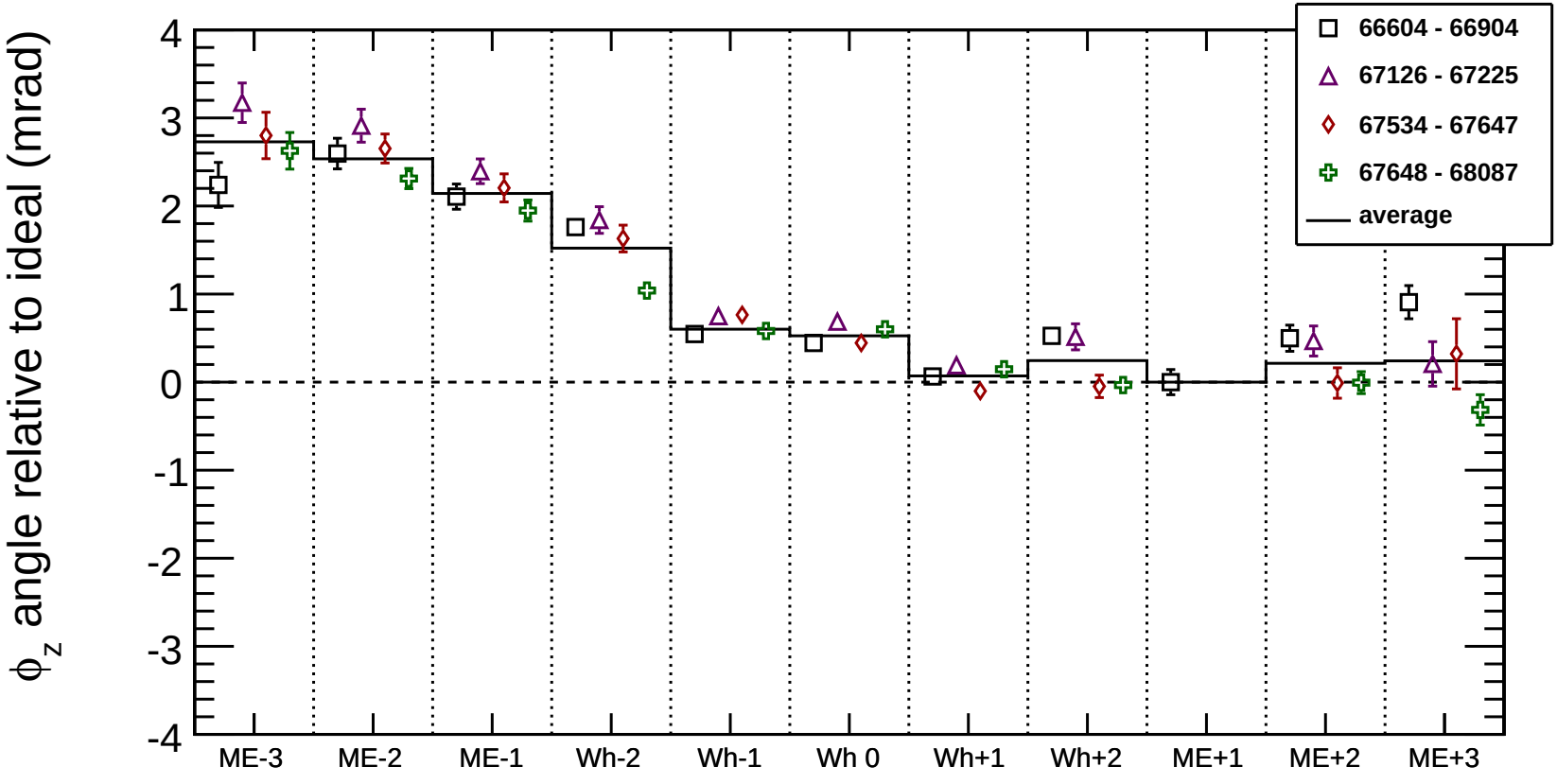
All alignment results (1/6)

- Four run regions with stable 3.8 T field
- Results depend on tracker alignment: this uses last night's final tracker alignment (HIP with survey constraints)
- Aligned CMS is *compressed* in z



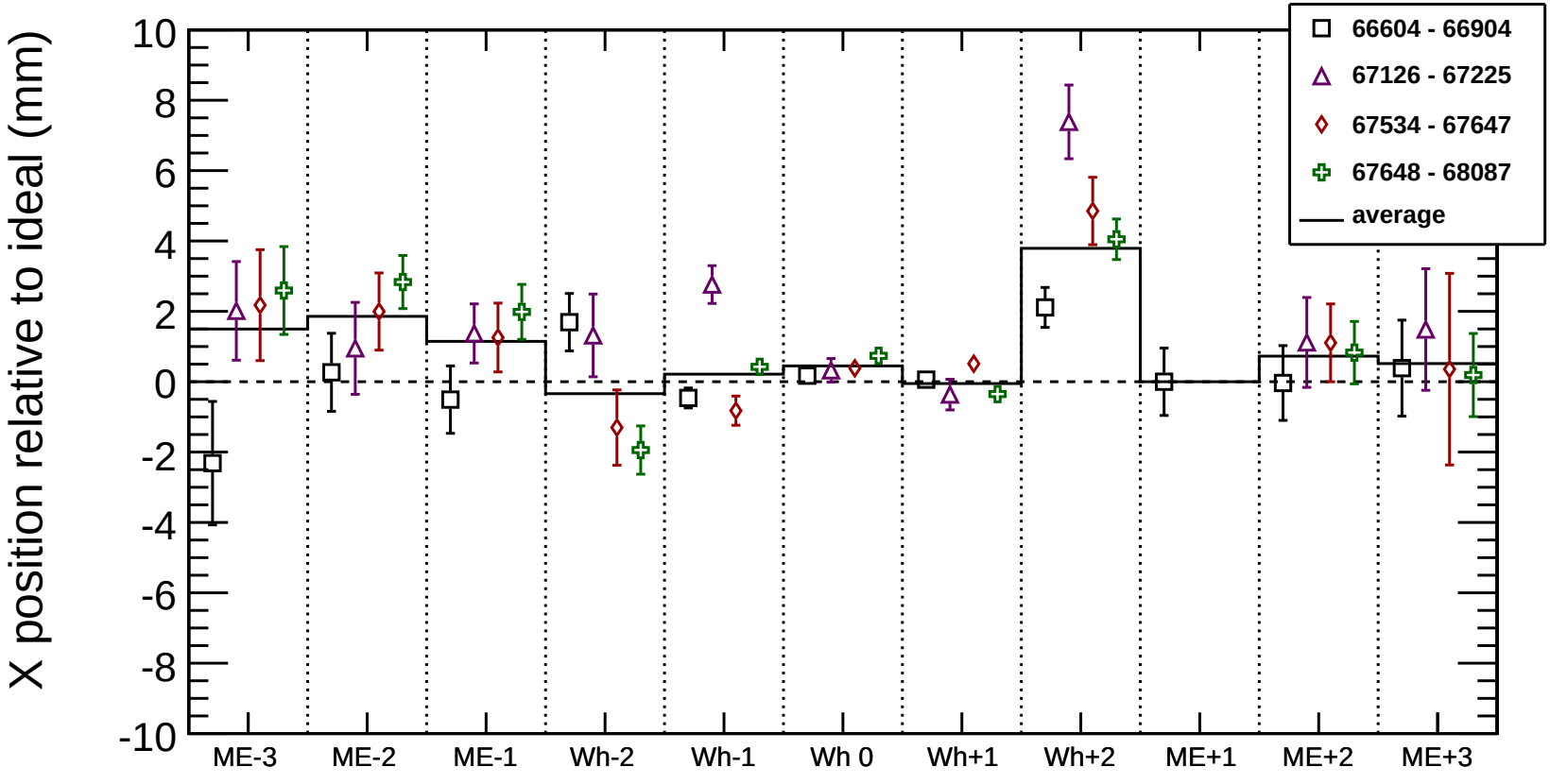
All alignment results (2/6)

- Four run regions with stable 3.8 T field
- Results depend on tracker alignment: this uses last night's final tracker alignment (HIP with survey constraints)
- ϕ_z is the rotation relative to tracker: essential for charge ratio



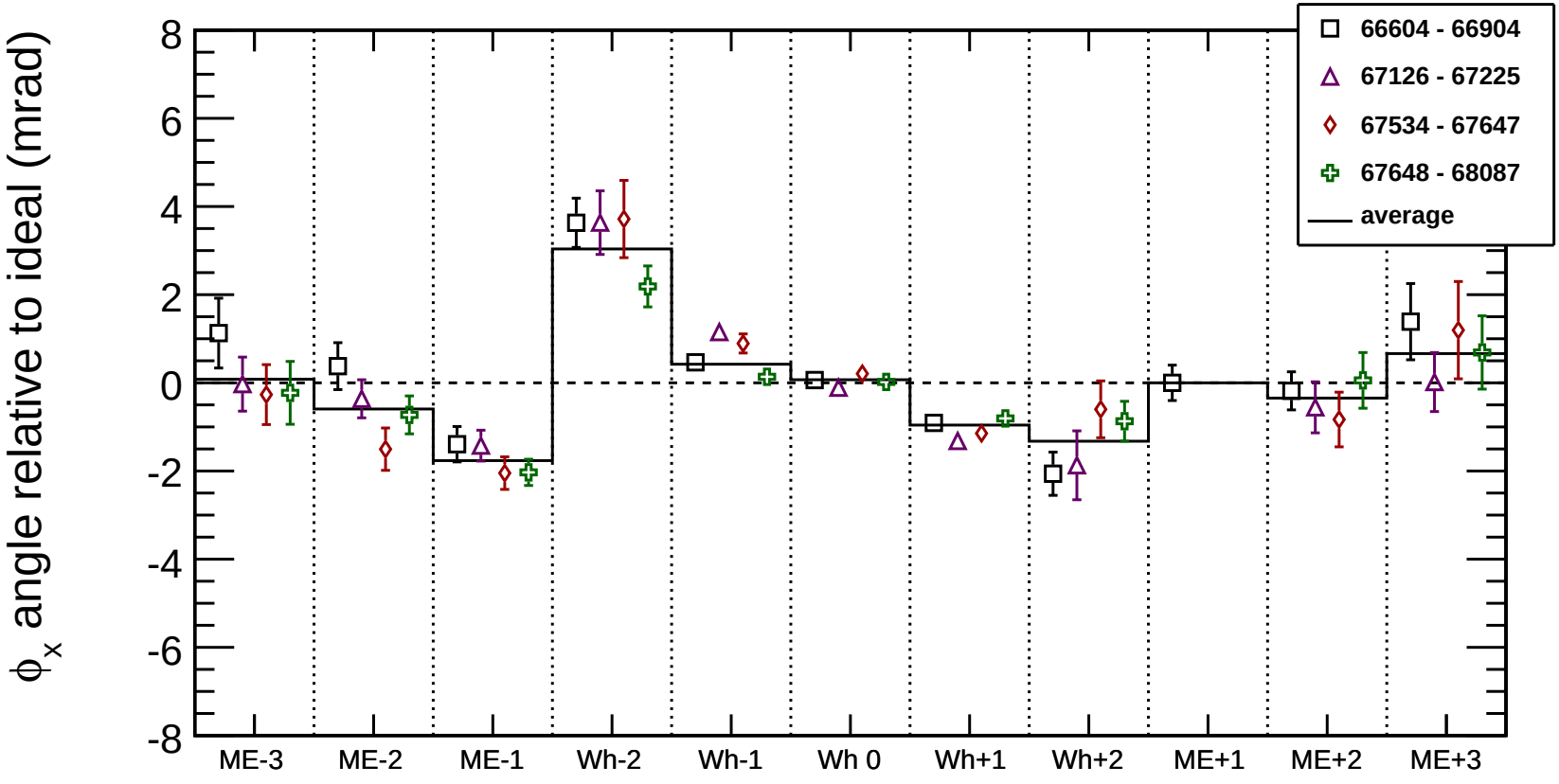
All alignment results (3/6)

- Four run regions with stable 3.8 T field
- Results depend on tracker alignment: this uses last night's final tracker alignment (HIP with survey constraints)
- x (horizontal) corrections



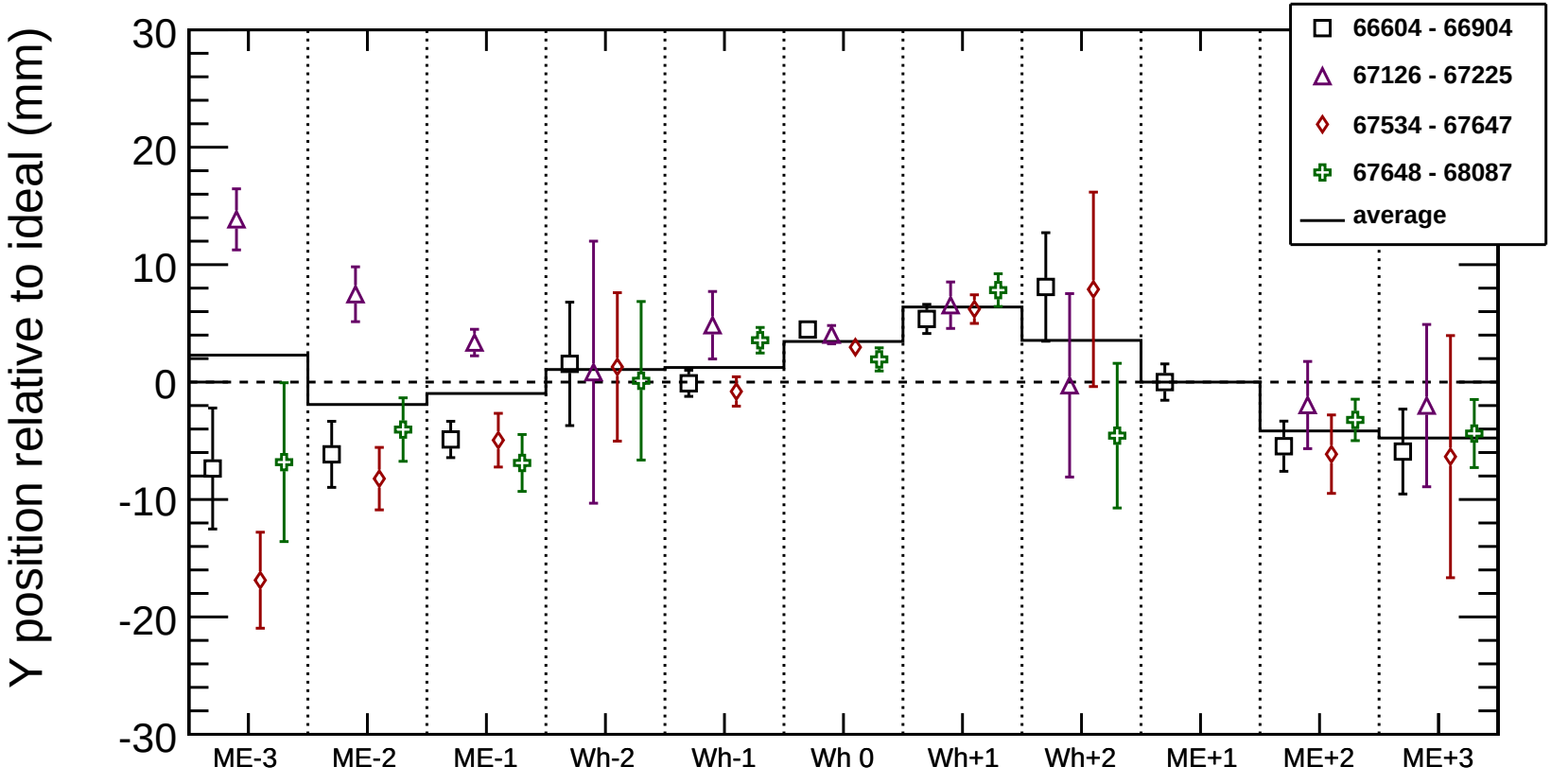
All alignment results (4/6)

- Four run regions with stable 3.8 T field
- Results depend on tracker alignment: this uses last night's final tracker alignment (HIP with survey constraints)
- ϕ_x rotation around the x axis, essentially a z difference between top and bottom



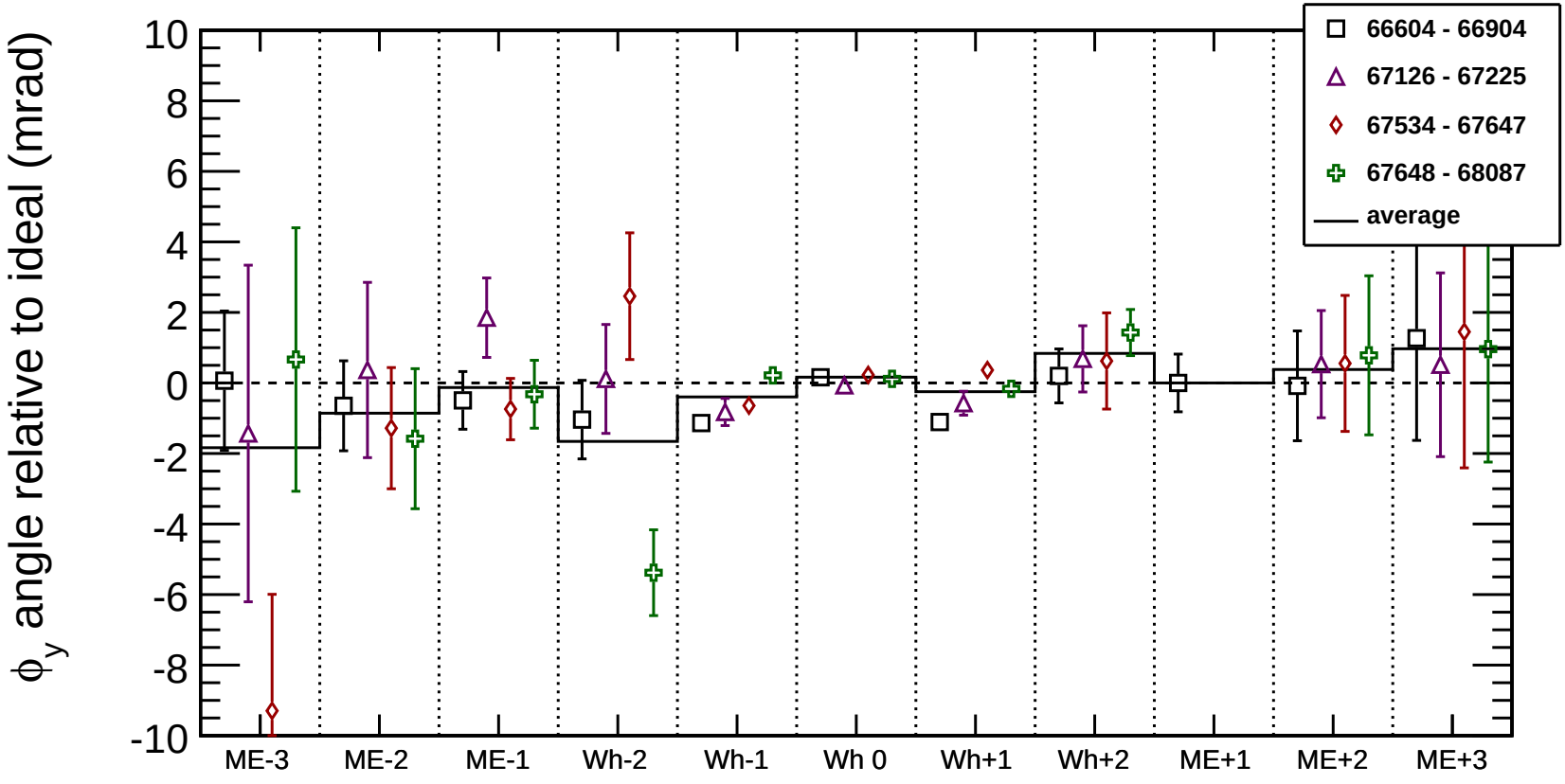
All alignment results (5/6)

- Four run regions with stable 3.8 T field
- Results depend on tracker alignment: this uses last night's final tracker alignment (HIP with survey constraints)
- y is poorly determined by vertical cosmic rays, we weighted the profile plots to prefer tracks with good measurements



All alignment results (6/6)

- Four run regions with stable 3.8 T field
- Results depend on tracker alignment: this uses last night's final tracker alignment (HIP with survey constraints)
- same for ϕ_y (best determined by non-vertical tracks), also weighted



Conclusions

- Ideal wheel/disk positions (no correction) are known to be wrong by millimeters or milliradians; these corrections are *at least* a step in the right direction
- $p \to \infty$ fit emphasizes the highest p_T tracks and removes sensitivity to multiple scattering and $\vec{B}$ field errors
- Consistent run-by-run (different $\vec{B}$ field ramp-up periods)
- There seems to be a good correlation between the two algorithms, HIP and MillePede (we should overlay them, once new tracker alignment is incorporated)
- ϕ_z is especially important for charge ratio; getting these constants in the first CRAFT re-processing (with refinements later) will help this analysis to move forward before the second re-processing